

SEP 30 1991

**A Database of Functional Neuroanatomy
Derived From Human Brain Images**

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The goal of the **BrainMap** project is to promote efficient compilation, analysis, and dissemination of the rapidly growing body of information about the functional organization of the human brain which can be provided by medical imaging techniques such as PET and MRI. We have developed highly quantitative image analysis tools for PET which provide spatial localization of brain function in a standardized spatial frame (AC-PC reference frame). Database strategies have been developed to specifically address the needs of brain mapping.

Two operational prototypes exist for the BrainMap strategy: 1) a published-literature-derived database in the Macintosh/Supercard environment, 2) a raw-data-derived database in the Unix/SQL environment. The former prototype is referred to as BrainMap-Mac and the latter as BrainMap-SQL. The specific aims of this project are to increase the functionality and data content of these two prototypes.

BrainMap Mac:

Most of our efforts during this quarter were devoted to the Macintosh version of BrainMap. The BrainMap-Mac software development task has four components: (1) Search Windows (mostly conceived, partially designed; partially operational), (2) SQL interface (partly conceived; partly designed; not operational), (3) Review Windows (partly conceived; partly designed; not operational), and 4) Report Generation (partly conceived; partly designed; not operational). These components are outlined and illustrated graphically in the pages at the end of this report. Software development is proceeding in a timely fashion, and at present we see no major problems with completing this portion of the project on time.

We've begun coding the **Search Windows** which provide user



interaction for searching through a BrainMap database. The design functionality of the windows are as follows:

1. *Search Criteria Window* - This is the home window for searching. This window contains five search criteria subwindows where selections can be entered, edited, and cleared. Logical comparison between the selections is provided. A button is available to clear all search criteria windows at once. Once criteria subwindow selections are made a search is initiated by pressing the search button. A search will produce a filtered subset of the original database with the number of matching records indicated. The resulting subset then becomes the current database. Using this scheme subsequent searches can be applied to further filter a current database. Options are provided to return to the previous database or return to the full (unfiltered) database. Pressing the View Set button causes the program to branch to the Review Home Window where users can review and analyze the data which has been isolated from the remainder of the database.

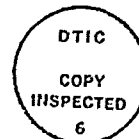
2. The Search Criteria Window categories button will provide a list of the major search categories: *Reference Criteria*, *Location Criteria*, *Behavior Criteria*, and *Protocol Criteria*. When selected each of these categories will open new windows with options for the selection of field values for searching. Selected fields can be assigned logical attributes of and, or, or not to help isolate information within the database.

a. The *Reference Criteria* window will allow separate selection of authors, journals, and keyword fields from lists of current values for each field. A date range can be used to isolate references falling within a specified time interval.

b. The *Location Criteria* window provides a means to search for data containing coordinates (AC-PC reference frame) which fall within a specified radial distance of a center coordinate. The center coordinate can be specified by typing into a selection box or using a mouse to point at the desired location on a graphic plot. The mouse selection uses the plot window (activated by the plot button) to display coronal, sagittal, and transverse plots of the brain. Additionally, location search criteria can be selected regionally by anatomical sites (lobes of the cerebral

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cortex). When an anatomical region is selected for searching, logical attributes can be applied.

c. The *Behavior Criteria* window contains subwindows for Behavioral Domain, Stimulus, Response, and Task Descriptor. The Behavioral Domain reflects cognitive, perceptual, and motor operations tasked by the experimental paradigm. Stimulus reflects the experimental stimulus conditions initially categorized by sensory modality. Response reflects the overt motor behaviors and other physiological variables (e.g. heart rate, EEG, etc.). The Task Descriptor is a keyword-based description of the task using a term or terms common in the field (e.g. anti-saccades, Stroop, Wisconsin-Card-Sort, etc.). This strategy has evolved through research, presentations and review by PET and neurology scientists and is not yet finalized.

d. The *Protocol Criteria* window will include categories which when selected will open windows relating to Population, Tracer, Modality, and Measurement. Population will contain fields such as group size, age, gender, diagnosis (if any), and handedness. Tracer will relate to the particular radionuclide, tracer which was labelled, and other information pertinent to the localization of the radiopharmaceutical within a subject. The Modality relates to the imaging system used to acquire tomographic images (e.g. PET, MRI, SPECT, etc.). Measurement will be used to identify what was actually measured by the imager (blood flow, tracer uptake, relaxation times for MRI, etc.). Items within this category generally will relate to the technical aspects of data acquisition.

A **major change** in software design was to separate the data files from the program files. This provides for better control, management and expendability of the BrainMap-Mac software. In order to accomplish this we had to rewrite a great deal of the Macintosh Supercard code.

We altered our strategy concerning BrainMap-Mac and **will implement a SQL version** of BrainMap on the Mac using SQL database software provided by Oracle (Redwood Shores, CA). This enhancement allows us to separate database files from the BrainMap-Mac program files. This will facilitate revisions and additions of versions sent to other sites.

Additionally, by implementing a SQL version of BrainMap on the Macintosh we will be able to field test the SQL capabilities. Since Oracle provides SQL software for both Mac and unix machines we will also use Oracle with the unix version of BrainMap. Porting SQL code to the unix environment will be much easier with this arrangement. We purchased the Oracle SQL database software and have begun planning the SQL interface with BrainMap-Mac.

The Locations-Coordinate Window was renamed Plot Window and has undergone a great deal of modification to enhance it's utility. These changes are summarized as follows:

1. Plot Window now functions with both the Search and Review functions.
2. Three view windows which provide Coronal, Sagittal, and Transverse plots of sections through the entire brain are now operational. A mouse is used to select the appropriate sections and to scroll back and forth through the plots.
3. The mouse can be used to identify coordinates by pointing at the plots.
4. Plots of multiple points are now possible.

Additionally, we are currently working on the following features of the plot window:

1. Creating a "silhouette" display for each of the three view directions.
2. Plot all points associated with a search rather than just those associated with a particular record onto the "silhouette".

Numerous cosmetic changes were made which affect the appearance and operation of windows. As few of these changes are as follows:

1. Added BrainMap Logo as opening screen.
3. Added 3-D buttons to all screens

Review Windows will allow users to review, edit, and plot the data selected by the Search Windows. The Review Windows will be accessible from the Home Window of the Search Window and vice versa. The Review Windows like the Search Windows are an integral part of the BrainMap software. Many of the subwindows of the Review Windows are updates of

previous versions of BrainMap-Mac. The Review Windows portion of BrainMap will deal with data returned from the SQL database as a result of searches. This will allow users to view all or selected portions of BrainMap databases.

Report Generation will rely heavily on the report generation capabilities of the SQL software, but will have a custom designed interface allowing users to select a variety of report formats.

BrainMap-SQL: The unix version of BrainMap was partly developed prior to the onset of this project. As stated above we will prototype much of the SQL portion of the project on the Macintosh. We have an early version of BrainMap-SQL which runs Sybase software on a unix workstation, but intend to move from Sybase to Oracle and to host the unix version of BrainMap-SQL on an IBM RS6000 workstation. The unix version of BrainMap will be much more robust in that it will support image-derived data rather than literature-derived data.

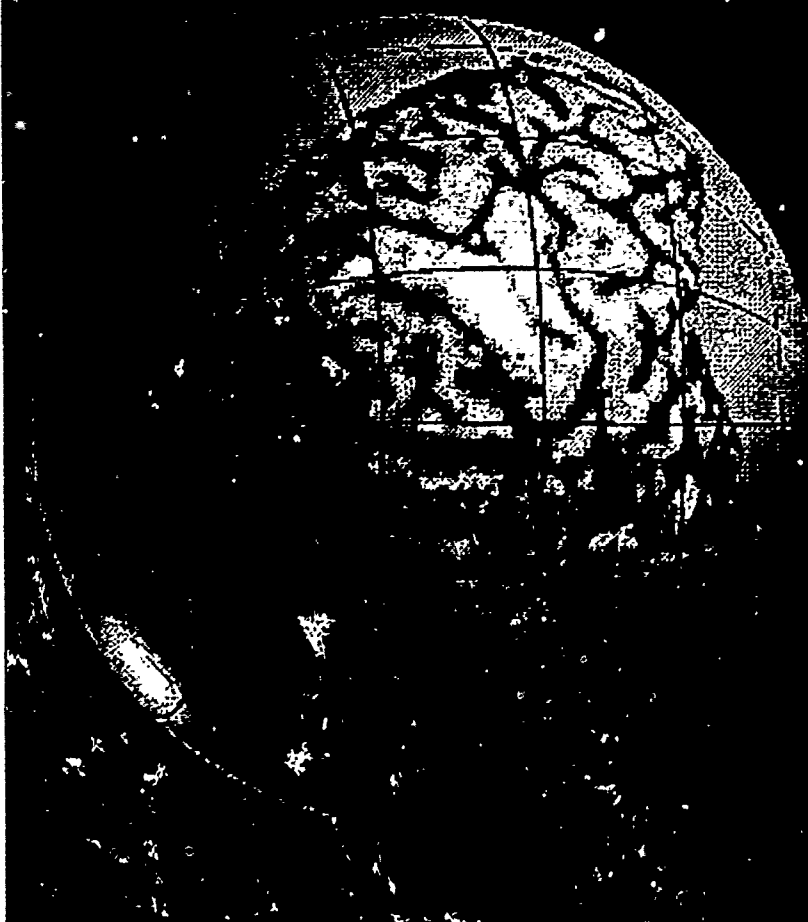
We've begun working on display and graphics features on the unix workstation using x-windows, but it is too early to report on the features and capabilities. We will concentrate more effort on the unix version of BrainMap after we have a functional SQL version running on the Macintosh.

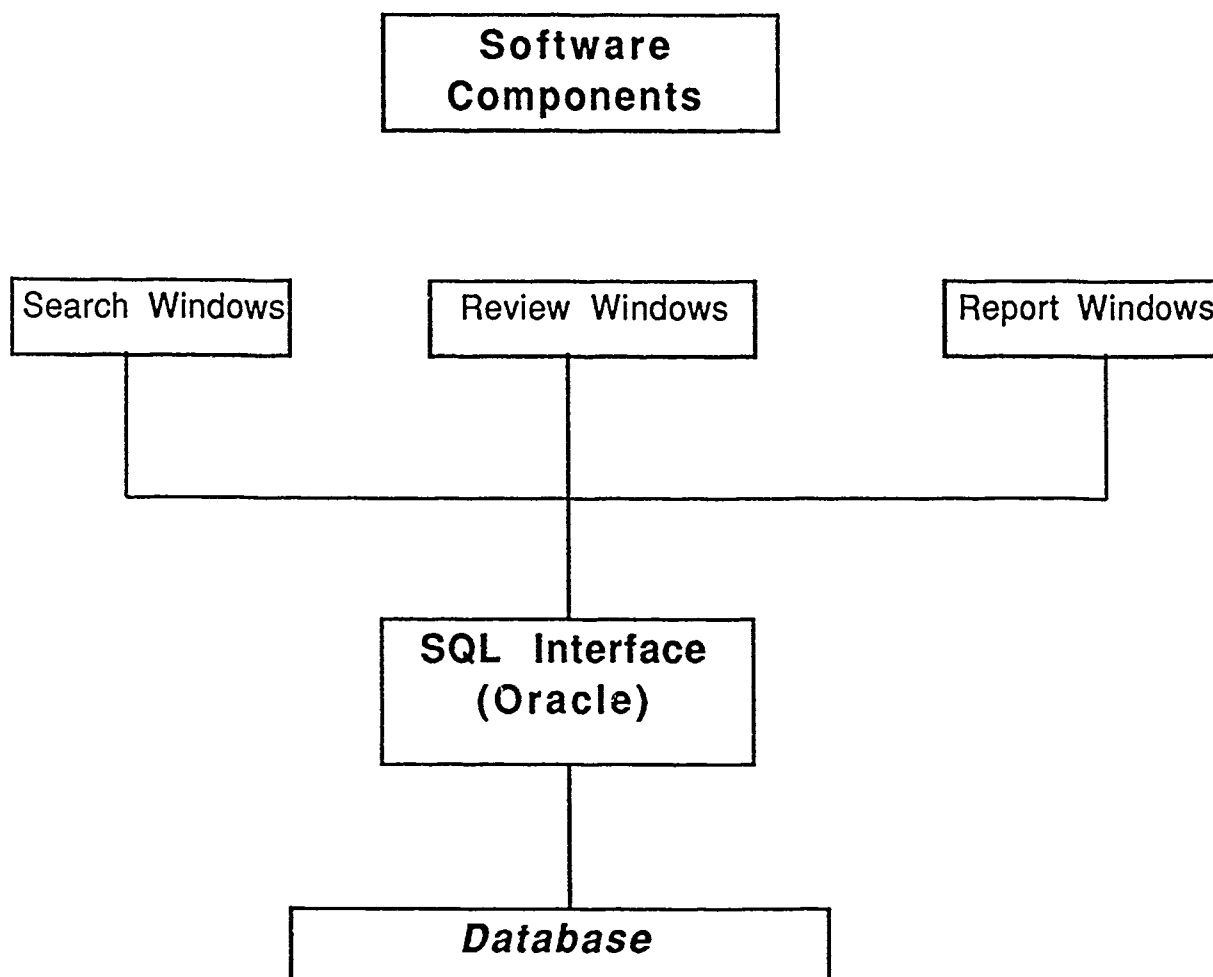
The pages which follow are to help you see the development plan, current status, and graphical nature of BrainMap-Mac as it stands now: The organization is as follows:

1. **The Logo** - This will be the opening screen for BrainMap
2. **Software Components Block Diagram** - This is a general outline of the organization of BrainMap software.
3. **Search Windows Block Diagram** - This is followed with graphic p[ages (unnumbered) which illustrate the appearance of the Search Windows. Some windows include data to illustrate how data will be presented.
4. **Review Windows Block Diagram** - This is also followed by graphic pages to illustrate the window appearance. One view for the Plot Window is provided.
5. **Behavioral Criteria** - This is a listing of the major category headings which will be used for search and review purposes.

BrainMap

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at San Antonio*





Search Windows

Search Criteria (Home Menu)

Search
View Set
Clear All
Previous Set

Reference Criteria

Author
Source
Keyword
Date

Location Criteria

Coordinate Position
Anatomical

Plot Window
(Select Coordinate)

Behavior Criteria

Behavioral
Domain
Stimulus
Response
Task Descriptor

Protocol Criteria

Population
Tracer
Modality
Measurement

BrainMap

Search Criteria

execute

Categories

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

clear

edit

Categories

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

clear

edit

Categories

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

clear

edit

Categories

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

clear

edit

Categories

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

clear

edit



BrainMap

Version 1.0

BrainMap

BrainMap

Brain

Brain

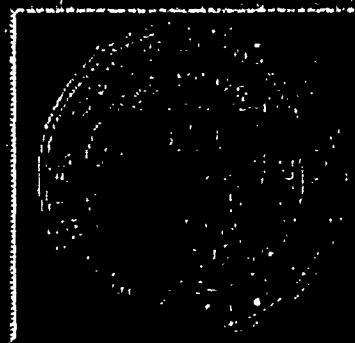
Fox, P.T.
Rachile, B.S.
Grover, R.K.
Washington, E.G.

BrainMap

Journal of Cognitive Neuros
Journal of Neuroscience
Journal of Neurosurgery
Nature

BrainMap

Brain
Branch
Broca



BrainMap

Location of the map

Coordinates of the map

EEG

EEG

EEG

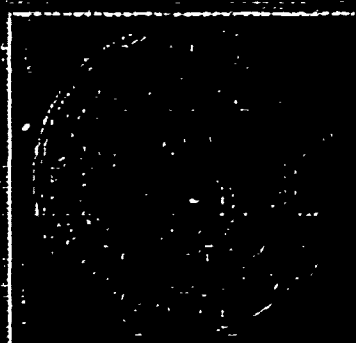
EEG

EEG

EEG

EEG

EEG



Applied to all



EEG

EEG

Frontal Lobes



Frontal Lobes, Left



Frontal Lobes, Right



Posterior Lobes



BrainMap

Behavioral Data

Behavioral Domain

Start

End

Stimulus

Start

End

Responses

Start

End

Task Description

Start

End



BrainMap

Experiment 1

Experiment 2

Experiment 3

Experiment 4

Experiment 5

Experiment 6

Carbon-11

Nitrogen-13

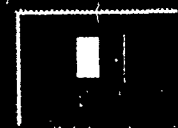
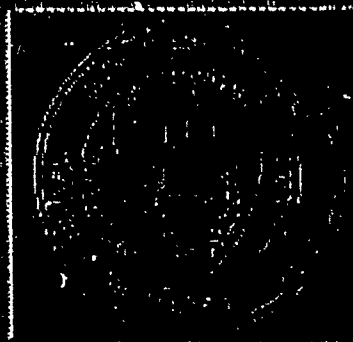
Oxygen-15

Experiment 7

Experiment 8

Experiment 9

Experiment 10



Review Windows

View

Paper References

Title
Source
Author
Affiliation

Locations

Title
Description
Left
Right

Plot

Coronal
Sagittal
Transverse

Tables

Title
Description
Table

Figures

Figure List
Display

Abstracts

Title
Source
Abstract

Behavior

Behavioral Domain
Stimulus
Response
Task Descriptor

Protocol

Population
Tracer
Modality
Measurement

BrainMap

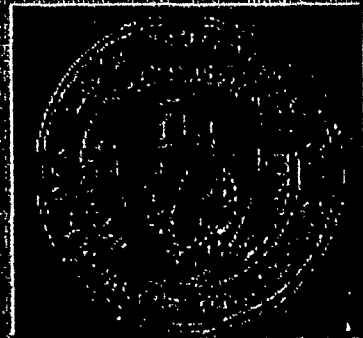
Page Reference

Title

Source

Author(s)

Publication



BrainMap

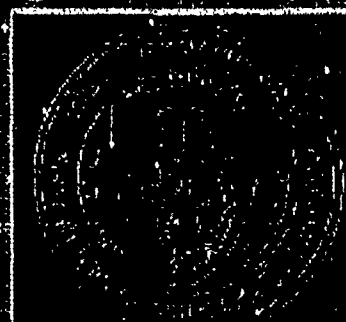
Project Location (City)

Title

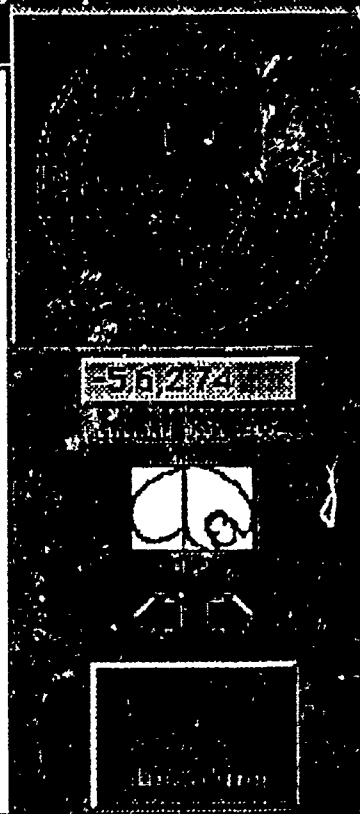
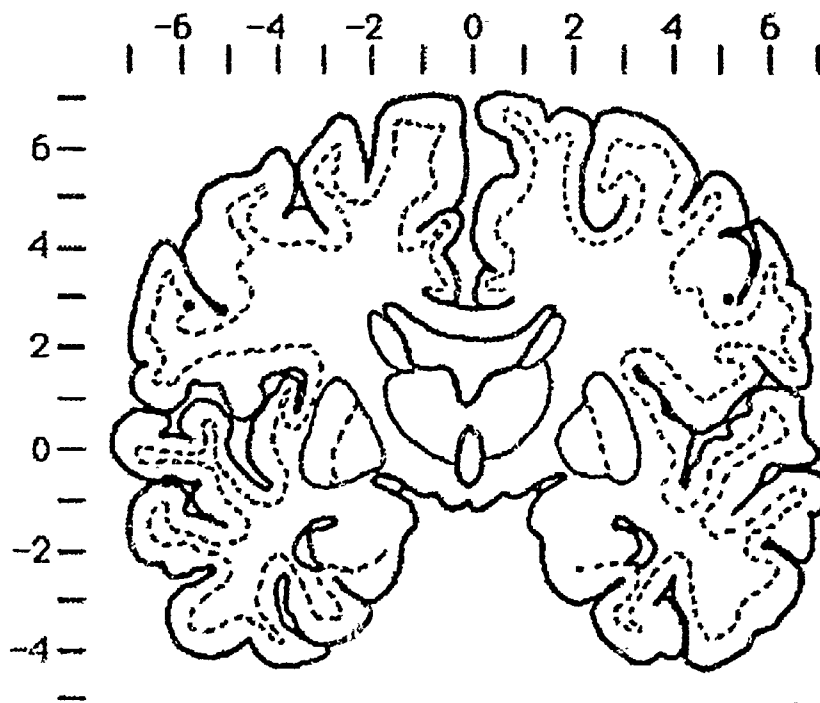
Location Description

Left

Right



2765



BrainMap							
Title							
Location Description							

ID, H	Stim Side	Axis					
		Rt-Lt		AP		Vertical	
		Rt	Lt	Rt	Lt	Rt	Lt

mean
SD

Title

Location Description

ID, H	Stim Side	Axis					
		Rt-Lt		AP		Vertical	
		Rt	Lt	Rt	Lt	Rt	Lt

mean
SD

BrainMap

BrainMap v1.0.0

Figure



BrainMap

Title

Source

Abstract



BrainMap

Participant: [REDACTED]

Behavioral Command

[REDACTED]

Stimulus

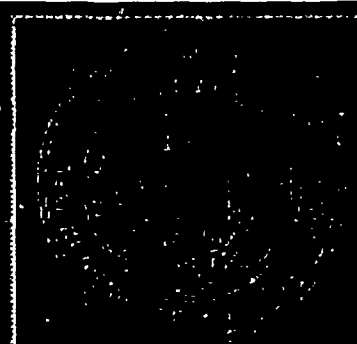
[REDACTED]

Response

[REDACTED]

Task Description

[REDACTED]



BrainMap

Paper Input

Project ID

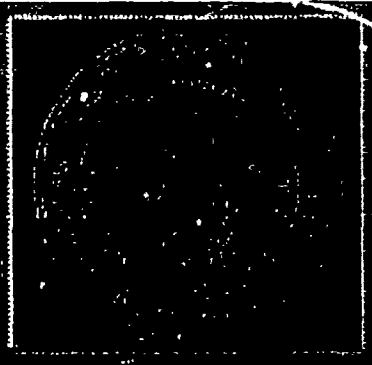
Gender



Model Type



Diagnostic Method



BEHAVIORAL CRITERIA

Behavioral Domains:

Passive
Perception
Motor Execution/Preparation
Cognition
Affect
Other
None

Stimulus Attributes:

SENSORY

Vision
Audition
Somesthesis
Olfaction
Gustation
Other
None

Overt Responses:

MOTOR

Ocular
Oral/Facial/Pharyngeal
Upper Limb
Lower Limb
Head/Neck
Trunk
Other
None

PHYSIOLOGIC VARIABLES

Galvanic Skin Response
EEG
Pulse Rate
Blood Pressure
Other
None

Task Descriptors:

anti-saccades, Stroop, Wisconsin-Card-Set, Mental Rotation, Other, None